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INVESTIGATION OF WILCOX MODEL 585B VERY HIGH FREQUENCY OMNIDIRE--ETC(U)
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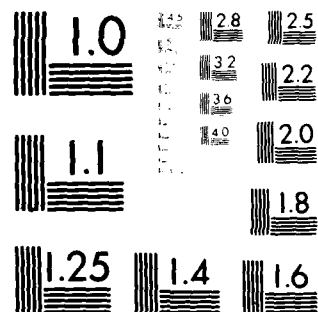
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MICROCOPY RESOLUTION TEST CHART
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Report No. FAA-RD-80-124
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**INVESTIGATION OF WILCOX MODEL 585B VERY HIGH
FREQUENCY OMNIDIRECTIONAL RADIO RANGE SYSTEM
(PART 2)**

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INTERIM REPORT

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16. Abstract <p>This report establishes a calibration procedure which employs a space modulation chart to adjust percent modulation for the Wilcox 585B very high frequency omnidirectional radio range (VOR) System. This procedure is recommended for solid-state VOR designed systems in which the rotatable goniometer has been replaced by a solid-state unit. Ground and airborne modulation tests were made using a spectrum analyzer for determining percent modulation. Results of these measurements indicated 1.5 percent modulation be added to the normal 30 percent modulation adjustment when made with the detector at counterpoise edge to provide equality between near and far afield modulation measurements.</p> <p>This project was accomplished under Technical Program Document (TPD) 04-309, subprogram 041-305-830. For further information contact Wayne Bell, ACT-100B.1, or Edward M. Sawtelle, Federal Aviation Administration (FAA) Technical Center Program Manager, ACT-100B.1, telephone FTS 8-346-3911, commercial (609) 641-8200, extension 3911. Results of this report will be included in a final report covering additional system elements on the Wilcox VOR system.</p>		13. Type of Report and Period Covered 9 Interim rept. May - June 1980
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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
y	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
in ²	square inches	6.5	square centimeters	cm ²
ft ²	square feet	0.09	square meters	m ²
yd ²	square yards	0.8	square meters	m ²
mi ²	square miles	2.6	square kilometers	km ²
	acres	0.4	hectares	ha
MASS (weight)				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
VOLUME				
cup	teacups	5	milliliters	ml
fl oz	tablespoons	15	milliliters	ml
c	fluid ounces	30	milliliters	ml
pt	cups	0.24	liters	l
qt	pints	0.47	liters	l
gal	quarts	0.96	liters	l
cu ft	gallons	3.8	liters	l
cu yd	cubic feet	0.03	cubic meters	m ³
	cubic yards	0.76	cubic meters	m ³
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

* 1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Length and Masses, Price \$2.25, SO Catalog No. C13.10.286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
km	kilometers	1.1	miles	mi
		0.6	miles	mi
AREA				
cm ²	square centimeters	0.16	square inches	in ²
m ²	square meters	1.2	square yards	yd ²
km ²	square kilometers	0.4	square miles	mi ²
ha	hectares (10,000 m ²)	2.5	acres	ac
MASS (weight)				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	ton
VOLUME				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
		1.06	quarts	qt
		0.26	gallons	gal
m ³	cubic meters	35	cubic feet	cu ft
		1.3	cubic yards	cu yd
TEMPERATURE (exact)				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

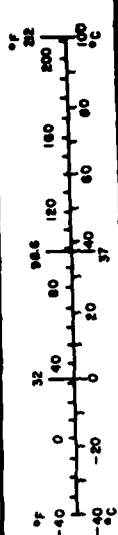
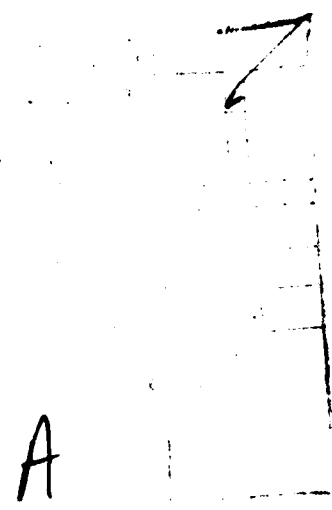


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INTRODUCTION

PURPOSE.

The purpose of this effort was to develop an acceptable calibration procedure to provide equal readings of 30 hertz (Hz) amplitude modulation (AM) between aircraft (far afield) and edge of counterpoise modulation indications with a Wilcox 585B very high frequency omnidirectional range (VOR) System.

BACKGROUND.

This interim report was prepared to satisfy request AAF-410-078-003, on Federal Aviation Administration (FAA) Form 9550-1, for the FAA Technical Center to investigate ground check error components. The request included a statement of the need for an acceptable calibration procedure for modulation measurements for a Wilcox model 585B station. A modified monitor/field detector to be used in the investigation is documented in the FAA Technical Center Letter Report No. NA-80-27-LR, "Investigation of Wilcox 585B VOR System (Part I)," by Wayne Bell.

DESCRIPTION OF TEST FACILITY.

Figure 1 shows the circular metal shelter for the Wilcox model 585B VOR System with the modified field detector in a bracket position. The equipment cabinets shown in figure 2 contain a complete dual transmitter/dual monitor system. Included in cabinet No. 1 are: the monitor, VOR test generator, local control panel, radiofrequency (RF) distribution unit, goniometer, transmitter, modulator/power supply/keyer, terminal board panel, and a blower. Since the cabinets are identical, the control unit and test generator can be installed in either cabinet.

DISCUSSION

TEST PROCEDURE AND RESULTS.

GENERAL. The tests were accomplished with the Wilcox test site operating at a frequency of 109.0 megahertz (MHz). Instrumentation employed in the testing include a Fluke model 8600K digital multimeter, a Hewlett-Packard model 7402A recorder, and a Hewlett-Packard spectrum analyzer comprised of a model 141T display unit, model 8553B RF unit, and a model 8552B intermediate frequency (IF) unit. Reference numbers 1 and 2 were used as guidance in formulating the detector calibration procedure. In addition, the methodology presented therein assured that ground measurements made with the calibrated field detector to obtain the space modulation chart did not introduce adjustment errors to the airborne measurements. The field detector diode nonlinearity required calibration for preparation of 30 Hz AM space modulation chart. The Wilcox model 585B VOR System has a solid-state goniometer instead of a mechanically rotatable unit contained in earlier VOR models. Consequently, the field detector is moved successively to the several counterpoise ground-check bracket locations to obtain intermediate values between the minimum and maximum. The measured values of field intensity correspond to radial position measurements made by keeping the field detector fixed and rotating the mechanical goniometer. The basic procedures in the FAA Handbook AF-6780.4A, "Maintenance of VHF Omnidirectional Equipment," were applied.

PROCEDURE SEQUENCE FOR SPACE MODULATION CHART.

The transmitter carrier power, adjusted to 100 watts, is fed to the northwest (NW) and southeast (SE) antenna slots.

MODIFIED
FIELD DETECTOR

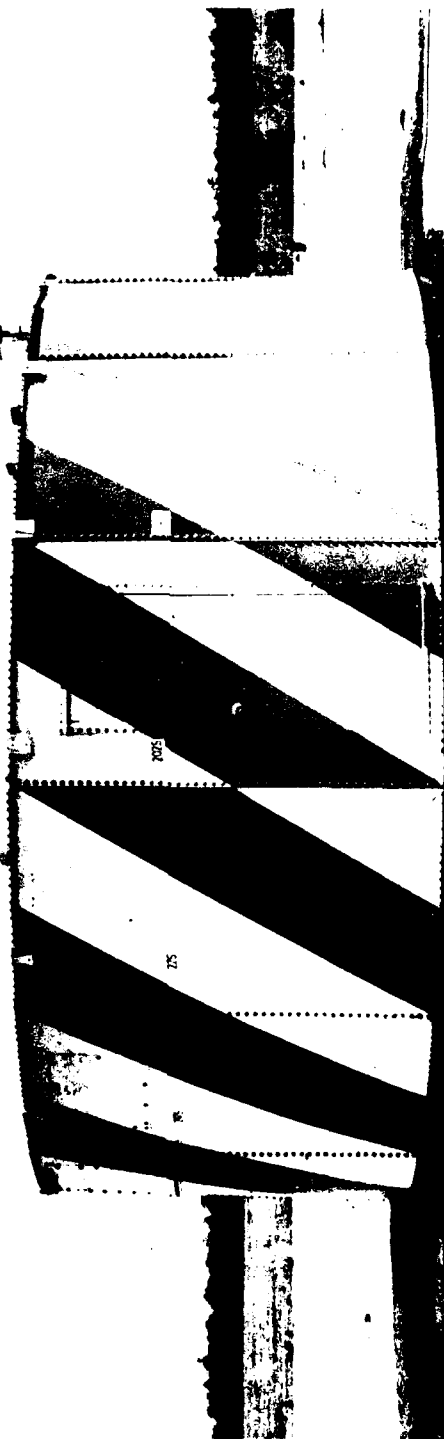
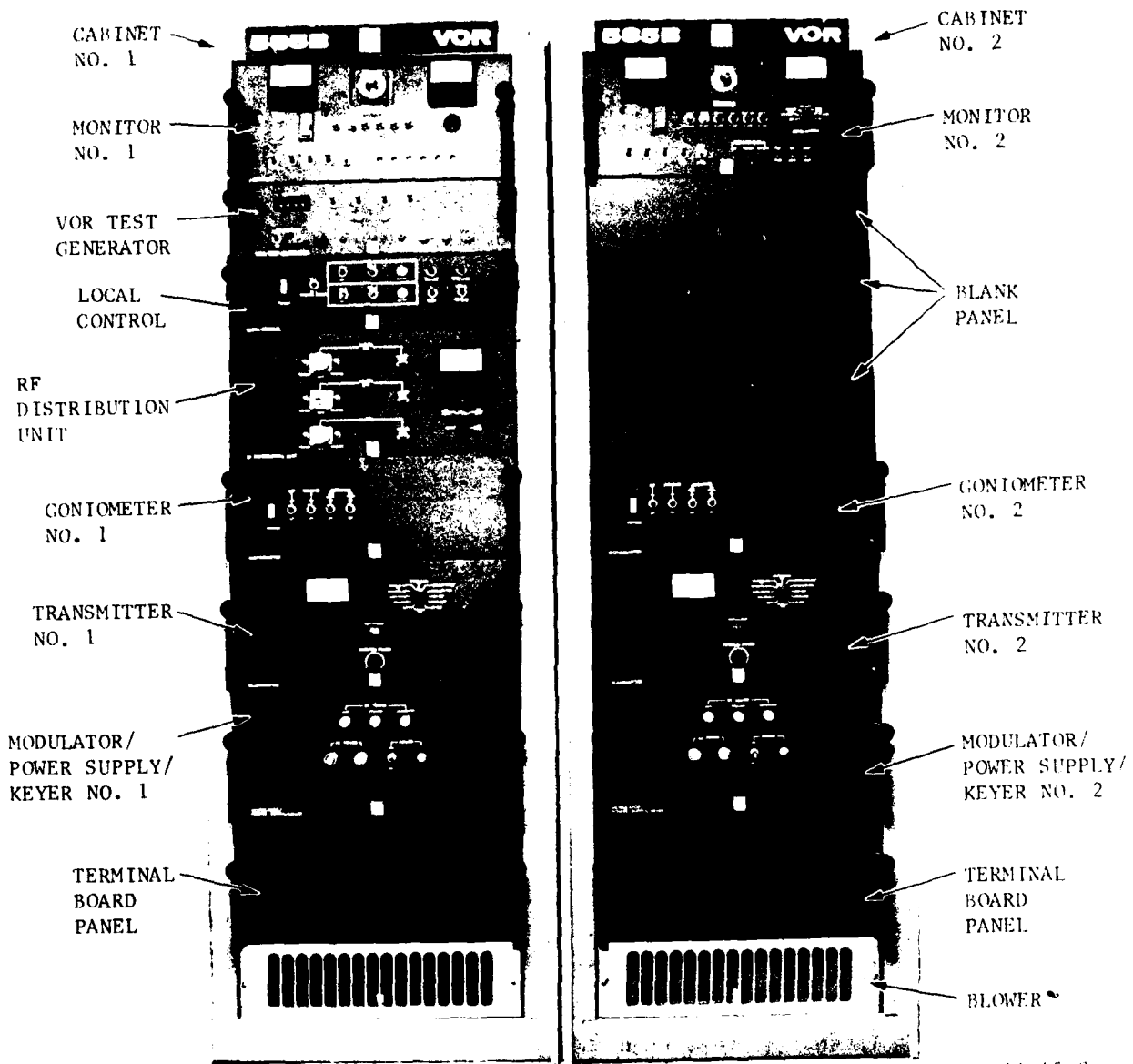


FIGURE 1. WILCOX MODEL 585B SHELTER



30-45-2

FIGURE 2. WILCOX MODEL 585B VOR CABINETS

This is sideband (SB) No. 1 (sine SB). To accomplish this, disconnect the carrier out cable and terminate it into a dummy load. Connect the SB No. 1 output cable to the jack where the carrier output cable was connected. Connect the SB No. 2 output cable to a dummy load. Turn the goniometer power off.

In preparation of a space modulation chart, measured values for the different parameters for various field detector angles are listed in table 1. An additional counterpoise ground check bracket is installed at an azimuth of 78.75 degrees, providing another field detector calibration position.

The following terms and sequence were used:

1. ρ = Field detector angle (used in lieu of goniometer angle)
2. $\theta = \rho + 45$ = Azimuth of field detector location
3. $\sin \rho$ = Natural trigonometric value
4. Percent modulation = $100 \frac{1 - \sin \rho}{1 + \sin \rho}$

Notice that values for parameters in lines 1, 2, 3, and 4 are related by their physical geometry. These values can be determined and entered in the table prior to any electrical measurements.

5. E = Field Intensity (measured by digital voltmeter)
 E_M = Maximum field intensity at $\rho = 90$ degrees

E and E_M were measured from the detected waveforms jack (J7) on the Wilcox model 585B monitor panel

$$6. E_{100} = 100 \times \frac{E}{E_{\max}} \text{ proportions the scale to 100}$$

$$8. \frac{E_{100}}{2.5} = \text{scale proportion to 40 for convenient use on the oscilloscope}$$

To develop column E of table 1 the sequence below is followed. Place the field detector at the 45 degree azimuth bracket and record the digital voltmeter reading at J7 on the monitor panel. Continue recording the voltmeter readings for each azimuth bracket location between 45 and 135 degrees. Figure 3 is a space modulation chart plotted from the data in table 1.

NEAR AND FAR AFIELD EQUALITY MEASUREMENT.

With the field detector at the 135 degree bracket position, the modulation was adjusted to 30 percent (using the standard oscilloscope technique employed at VOR field sites for measuring the minimum and maximum 30 Hz AM modulation). The spectrum analyzer was connected to a dipole antenna at the 135 degree bracket position (edge of counterpoise). Spectrums were then recorded using the yagi antenna located 500 feet from the counterpoise. Finally, airborne spectrums were recorded with the spectrum analyzer aboard the N-47 (Grumman Gulfstream) aircraft flying inbound at an altitude of 1,500 feet mean sea level (msl), at 140 knots, at 90 and 135 degree radials. During these tests no changes were made to the VOR System adjustments.

Using the spectrum analyzer technique, reference 2, the modulation ratio is described as the ratio of sideband (E_S) and carrier (E_C), i.e., $\frac{E_S}{E_C}$.

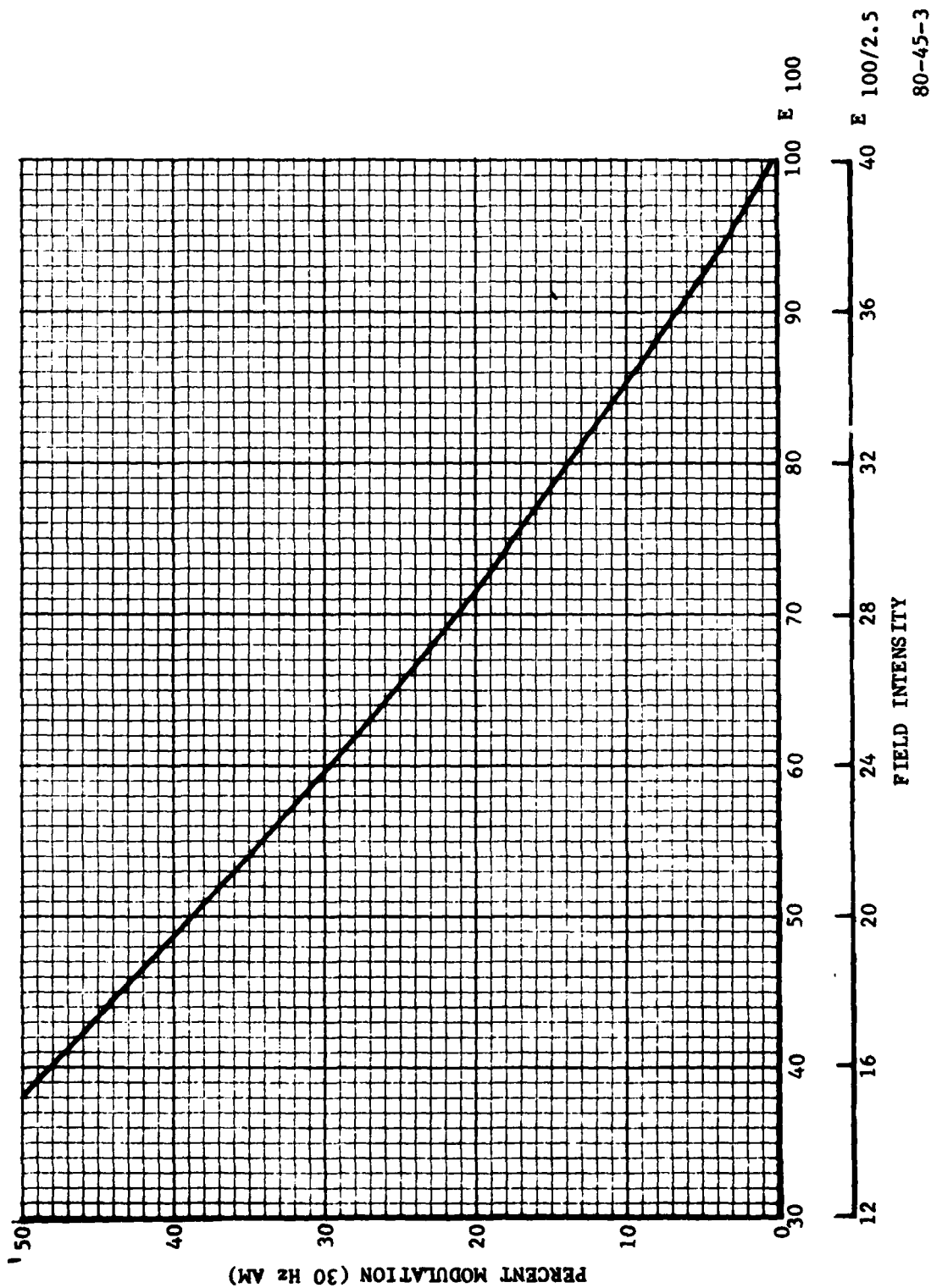


FIGURE 3. SPACE MODULATION CHART

TABLE 1. VALUES FOR SPACE MODULATION CHART

1	2	3	4
<u>Degrees</u>	<u>Degrees</u>	<u>Sin</u>	<u>Modulation percent</u>
0	45.0	0	100
22.5	67.5	0.383	44.6
33.75	78.75	0.556	28.57
45.0	90.0	0.707	17.16
67.5	112.5	0.924	3.96
90.0	135.0	1.00	0

5	6	7
<u>E Volts</u>	<u>E₁₀₀</u>	<u>E_{100/2.5}</u>
0.01	0	0
6.85	44.63	17.85
9.40	61.24	24.5
11.59	75.51	30.2
14.35	93.49	37.4
15.35	100	40

The values for this ratio were obtained from the recorded spectrums. Samples of the spectrums are shown in figure 4 with their average percent modulation for the different test conditions.

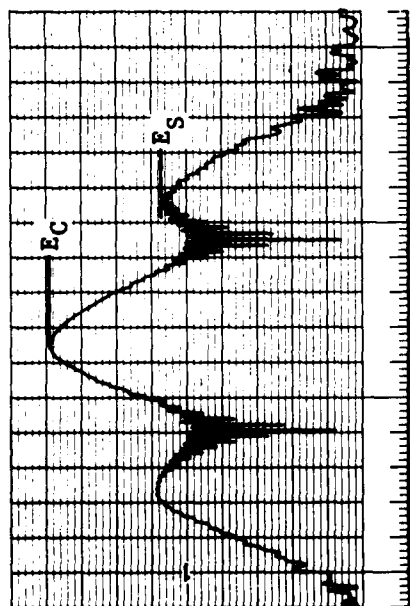
Average values were the same for the airborne spectrum data for the 90- and 135-degree radial flights inbound from 20 to 7 nautical miles range to the VOR site. The modulation value measured from the yagi antenna, located 500 feet from the counterpoise, was 0.3 percent greater than the airborne value and 1.6 percent greater than the value measured at the edge of the counterpoise. If the 500-foot ground measurement is considered far afield and averaged with the airborne measurements, the difference between near and far afield is a modulation percent difference of 1.45 percent. Moreover, without any compensation for the difference, the 30 percent optimum

adjustment would be within the tolerance of 25 to 35 percent levels listed in reference 3.

CONCLUSIONS

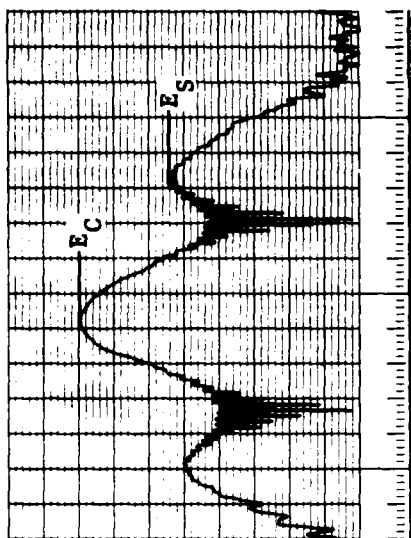
1. An acceptable procedure was developed for calibration of 30 hertz (Hz) amplitude modulation (AM) modulation for the Wilcox 585B very high frequency omnidirectional radio range (VOR). A small correction percentage provides equality of modulation calibration between edge of counterpoise and aircraft (far afield) measurements.

2. A spectrum analyzer technique to measure percent modulation provided accuracy to observe the small differences in near and far afield measurements.



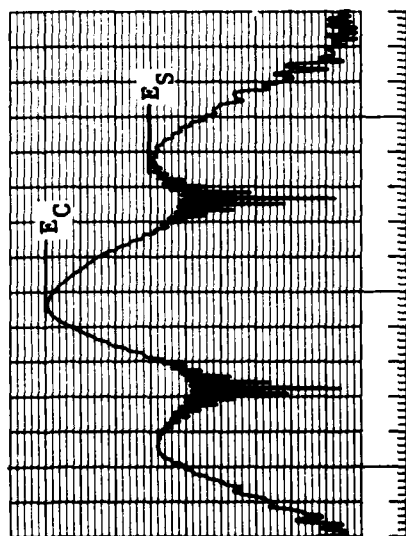
EDGE OF COUNTERPOISE

AVERAGE $E_S/E_C = 0.64 = 30$ PERCENT



135° RADIAL

500 FT (YAGI)
AVERAGE $E_S/E_C = 0.675 = 31.6$ PERCENT



INBOUND 20 NMI (140 KNOTS)
AVERAGE $E_S/E_C = 0.667 = 31.3$ PERCENT

HEWLETT PACKARD SPECTRUM ANALYZER SETTINGS

BANDWIDTH = 0.01 kHz

SCAN WIDTH = 0.02 kHz

SCAN TIME = 0.5 SEC/DIV

RECORDER CHART SPEED = 25 mm/SEC

FIGURE 4. SAMPLE SPECTRUM RECORDINGS

80-45-4

3. A small calibration percent difference 1.45 percent exists between near and far afield measured modulation values.

RECOMMENDATIONS

Based on the investigation results, it is recommended that:

1. The calibration procedure included herein for obtaining a space modulation be used for solid-state very high frequency omnidirectional radio range (VOR) systems.

2. In a Wilcox model 585B System employing a 21-foot diameter counterpoise, a modulation for 30 percent adjustment at the edge of the counterpoise be increased by 1.5 percent to make near and far afield measurements equivalent.

REFERENCES

1. Maintenance of VHF Omnidirectional Radio Range Equipment NE AFI, New England Region Supplement 6790.4A, March 16, 1979.

2. Kanen, Garth M., VHF Omnidirectional Radio Range (VOR) Electromagnetic Spectrum Measurements, Technical Note, Project 213-060-78, October 18, 1978.

3. United States Standard Flight Inspection Manual, FAA Handbook OA PB200.1, Section 201.5, Chg 27, May 1977.

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